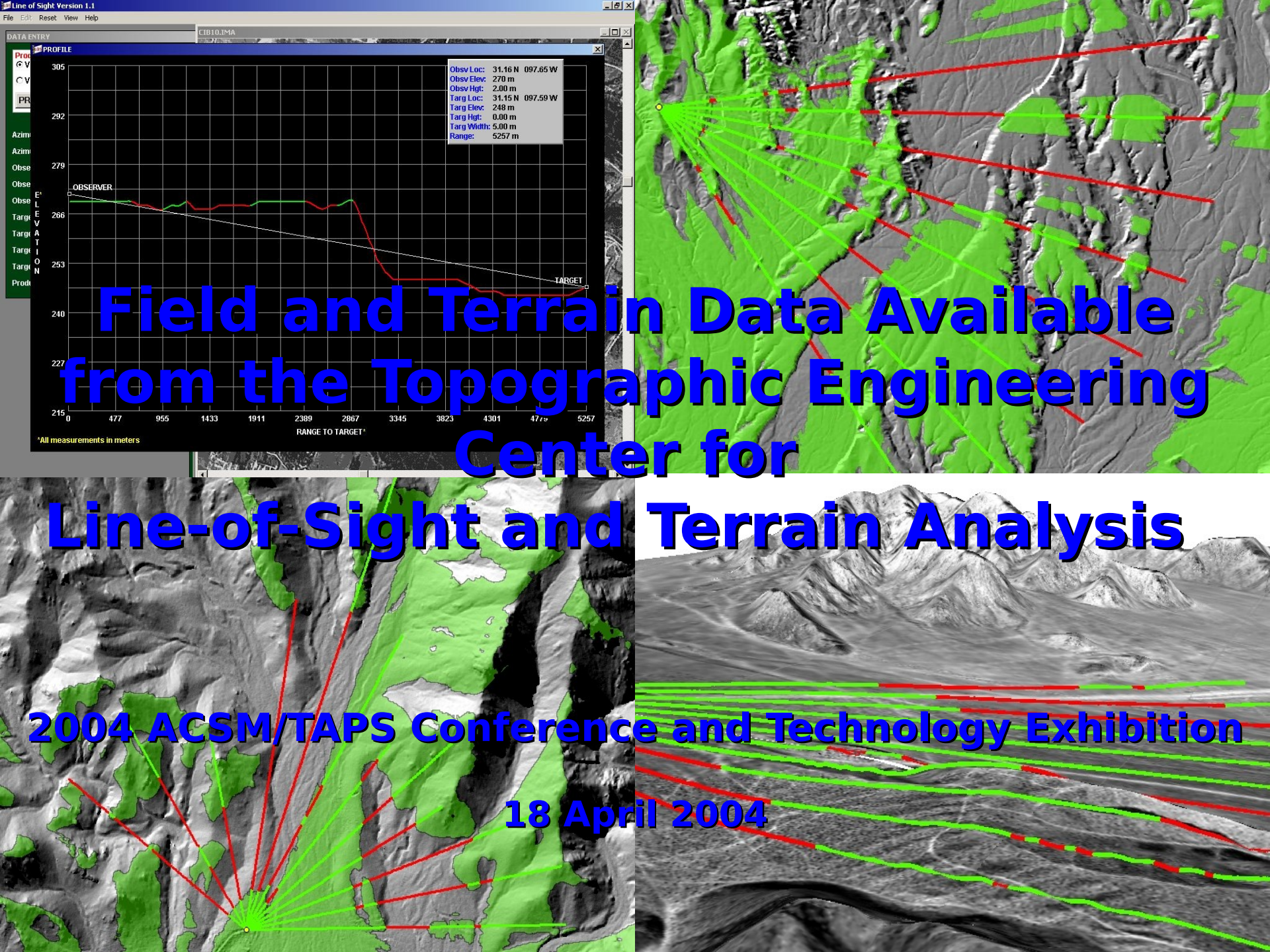

Line of Sight Version 1.1
File Edit Reset View Help
DATA ENTRY
CIB10.IMA
PROFILE
Obsv Loc: 31.16 N 097.65 W
Obsv Elev: 270 m
Obsv Hgt: 2.00 m
Targ Loc: 31.15 N 097.59 W
Targ Elev: 248 m
Targ Hgt: 0.00 m
Targ Width: 5.00 m
Range: 5257 m
OBSERVER
TARGET
ELEVATION
RANGE TO TARGET*
*All measurements in meters
Field and Terrain Data Available from the Topographic Engineering Center for
Line-of-Sight and Terrain Analysis
2004 ACSM/TAPS Conference and Technology Exhibition
18 April 2004

Data Sets

Field Data and High Resolution DEM Coverage

- Field data in Access, Excel, or Text Formats
- High resolution (1 - 5 meter) photogrammetrically derived DEMs in Arc ASCII, ASCII, GeoTIFF, ERDAS .img formats, etc.
  - **Fort Benning, GA**
  - **Fort Hood, TX**
  - **Irwin East, CA (National Training Center)**
  - **Irwin West, CA (National Training Center)**
  - **Twentynine Palms, CA**
  - **Yakima, WA**

Field Data Characteristics

Test Area	Collected Field Points	# of Observer Positions	# of Azimuths	Sampling Interval (meters)	Std. Deviation of Field Point Elevations (meters)*	
Fort Benning A**		18342	6	41	0.9	7
Fort Benning B**		18342	6	41	0.9	7
Fort Hood	28412	7	51	3.5	7	
Irwin East	37077	5	35	3.5	36	
Irwin West	31483	4	35	3.5	53	
29 Palms	8163	3	29	3.5	28	
Yakima	34109	5	39	3.5	34	
Yuma	36843	5	61	5.0	22	

Observer heights range between 1.075 meters and 1.75 meters.

Target heights range between 1.0 meters and 3.067 meters.

*Terrain roughness (sigma-t) of the elevations of the field points is moderate (standard deviation of 18 – 61 meters) for all test areas except Fort Benning which is smooth (standard deviation of < 18 meters).

** The same field points at Fort Benning were recorded

Field Data in Access Database

Microsoft Access - [YumaSite3 : Table]

File Edit View Insert Format Records Tools Window Help

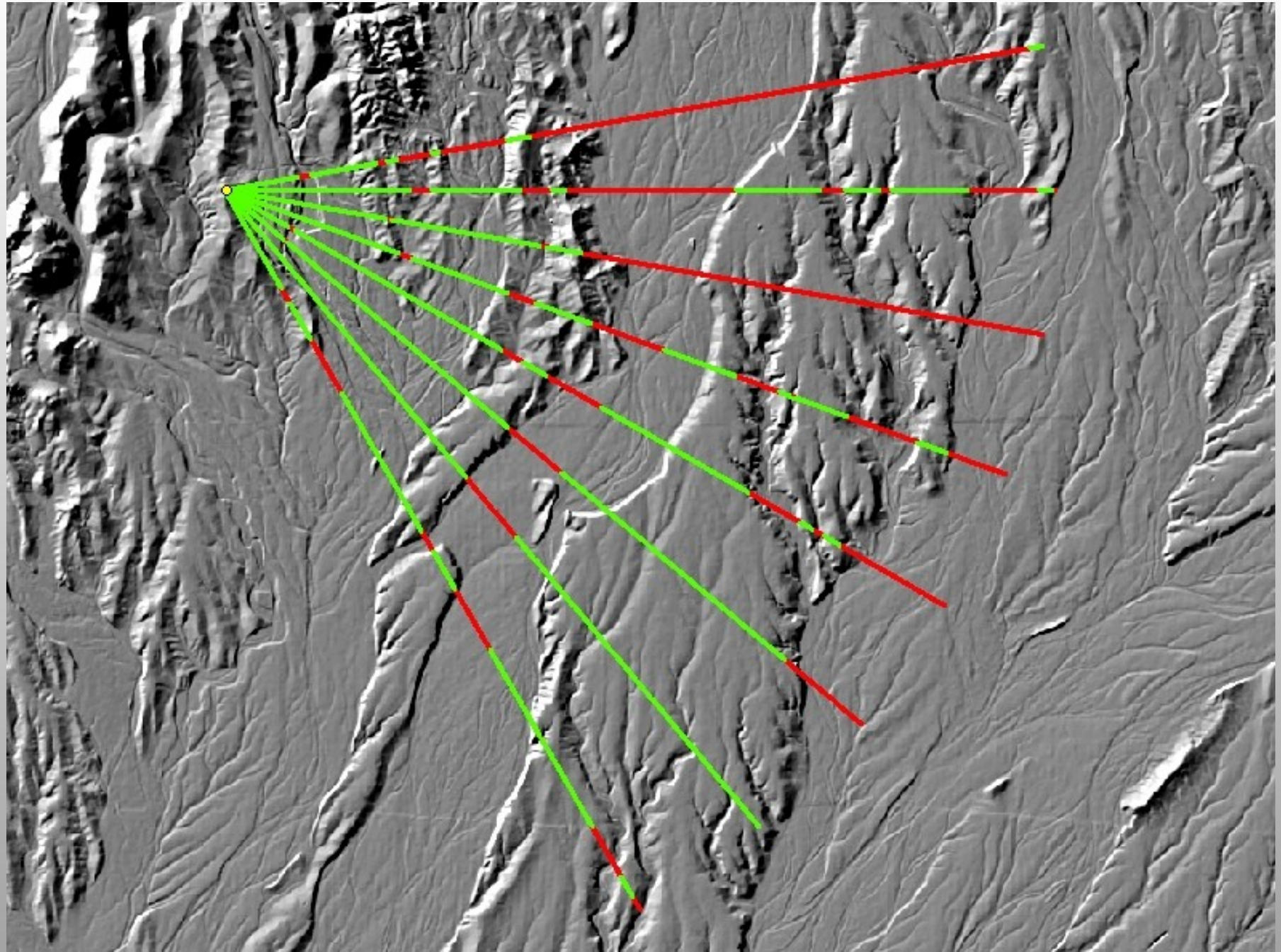
Counter	SiteNum	AzimuthNum	SensorX	SensorY	SensorZ	TargetX	TargetY	TargetZ	SensorTargetDist	AzimuthCounter	FieldLOS
1501	3	5	745278.8	3669481.8	1.618	745169.8	3669781	3.067	318.46	65	1
1502	3	5	745278.8	3669481.8	1.618	745168.1	3669785.8	3.067	323.5	66	1
1503	3	5	745278.8	3669481.8	1.618	745166.5	3669790.2	3.067	328.29	67	1
1504	3	5	745278.8	3669481.8	1.618	745164.8	3669794.8	3.067	333.09	68	1
1505	3	5	745278.8	3669481.8	1.618	745163.1	3669799.5	3.067	338.13	69	1
1506	3	5	745278.8	3669481.8	1.618	745161.4	3669804	3.067	342.94	70	1
1507	3	5	745278.8	3669481.8	1.618	745159.8	3669808.8	3.067	347.98	71	1
1508	3	5	745278.8	3669481.8	1.618	745158.1	3669813.2	3.067	352.76	72	1
1509	3	5	745278.8	3669481.8	1.618	745156.4	3669818	3.067	357.8	73	1
1510	3	5	745278.8	3669481.8	1.618	745154.8	3669822.5	3.067	362.61	74	1
1511	3	5	745278.8	3669481.8	1.618	745153.1	3669827	3.067	367.42	75	1
1512	3	5	745278.8	3669481.8	1.618	745151.4	3669831.8	3.067	372.46	76	1
1513	3	5	745278.8	3669481.8	1.618	745149.8	3669836.2	3.067	377.24	77	1
1514	3	5	745278.8	3669481.8	1.618	745148.1	3669841	3.067	382.28	78	0
1515	3	5	745278.8	3669481.8	1.618	745146.4	3669845.5	3.067	387.09	79	1
1516	3	5	745278.8	3669481.8	1.618	745144.7	3669850	3.067	391.89	80	1
1517	3	5	745278.8	3669481.8	1.618	745143	3669854.8	3.067	396.93	81	1
1518	3	5	745278.8	3669481.8	1.618	745141.3	3669859.2	3.067	401.74	82	0
1519	3	5	745278.8	3669481.8	1.618	745139.7	3669864	3.067	406.76	83	0
1520	3	5	745278.8	3669481.8	1.618	745138	3669868.5	3.067	411.57	84	0
1521	3	5	745278.8	3669481.8	1.618	745136.3	3669873.2	3.067	416.61	85	0
1522	3	5	745278.8	3669481.8	1.618	745134.6	3669877.8	3.067	421.41	86	0
1523	3	5	745278.8	3669481.8	1.618	745132.9	3669882.2	3.067	426.22	87	0
1524	3	5	745278.8	3669481.8	1.618	745131.3	3669887	3.067	431.24	88	0
1525	3	5	745278.8	3669481.8	1.618	745129.6	3669891.5	3.067	436.04	89	0
1526	3	5	745278.8	3669481.8	1.618	745127.9	3669896.2	3.067	441.08	90	0
1527	3	5	745278.8	3669481.8	1.618	745126.2	3669900.8	3.067	445.89	91	0
1528	3	5	745278.8	3669481.8	1.618	745124.6	3669905.2	3.067	450.7	92	0
1529	3	5	745278.8	3669481.8	1.618	745122.9	3669910	3.067	455.71	93	0
1530	3	5	745278.8	3669481.8	1.618	745121.2	3669914.5	3.067	460.52	94	0
1531	3	5	745278.8	3669481.8	1.618	745119.6	3669919.2	3.067	465.56	95	0
1532	3	5	745278.8	3669481.8	1.618	745117.9	3669923.8	3.067	470.37	96	0
1533	3	5	745278.8	3669481.8	1.618	745116.2	3669928.5	3.067	475.41	97	0
1534	3	5	745278.8	3669481.8	1.618	745114.5	3669933	3.067	480.21	98	0
1535	3	5	745278.8	3669481.8	1.618	745112.9	3669937.5	3.067	485	99	0

Record: 1501 of 5969

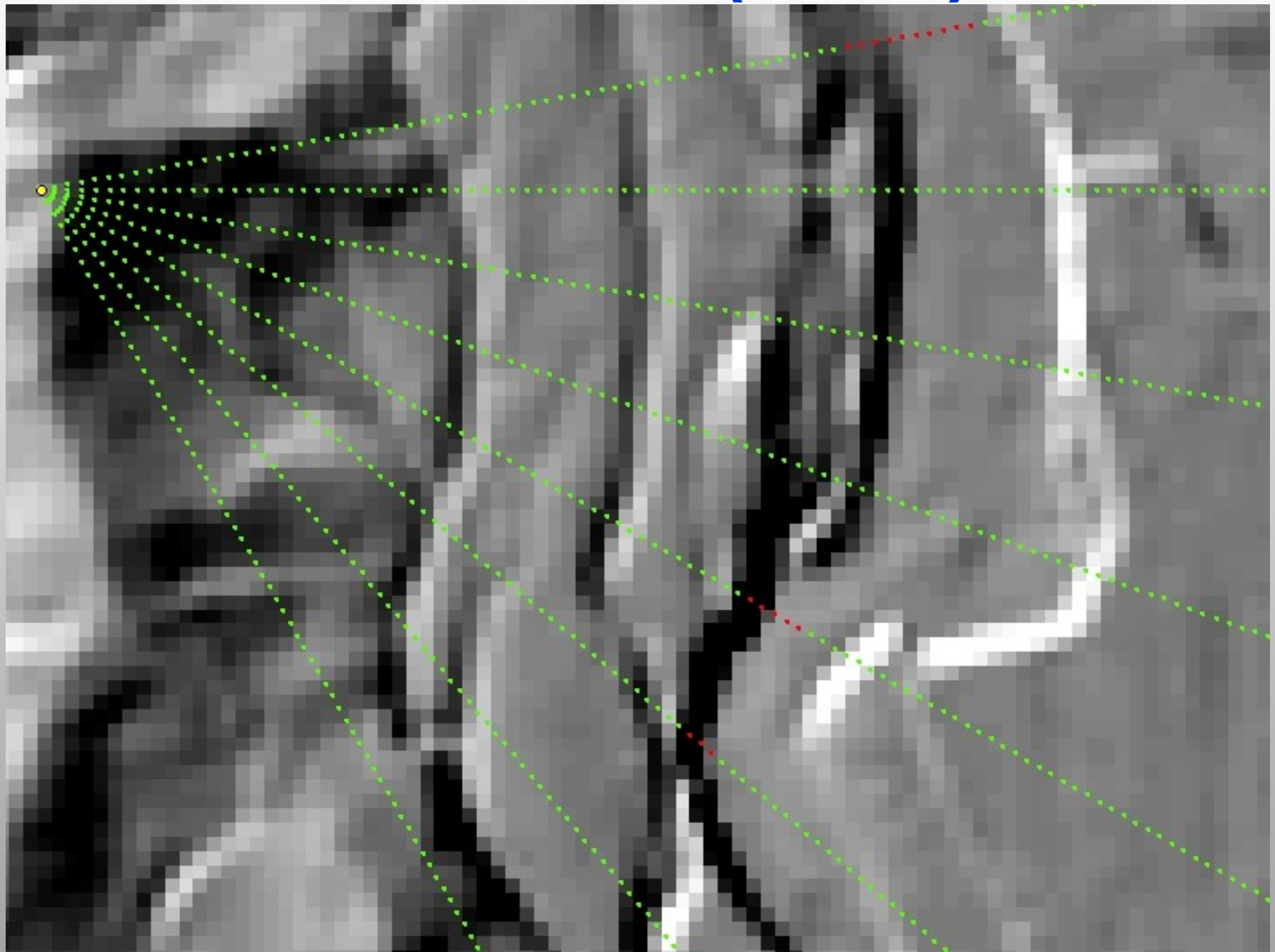
Datasheet View

FieldLOS of 1 = Visible to Observer, FieldLOS of 0 = Masked to

Yuma Site 1 – 5224 Observed Points



Yuma Site 1 (detail)



Overview of Methodology

- **Produce multi-vendor, geo-referenced viewsheds at defined observer locations that cover the extent of the collected field data and duplicate the observer and target heights used in the field.**

  (Viewshed applications should be able to support floating point Z values when tested against TEC's photogrammetric DEMs.)

  (No re-projection or re-sampling of DEMs is performed.)

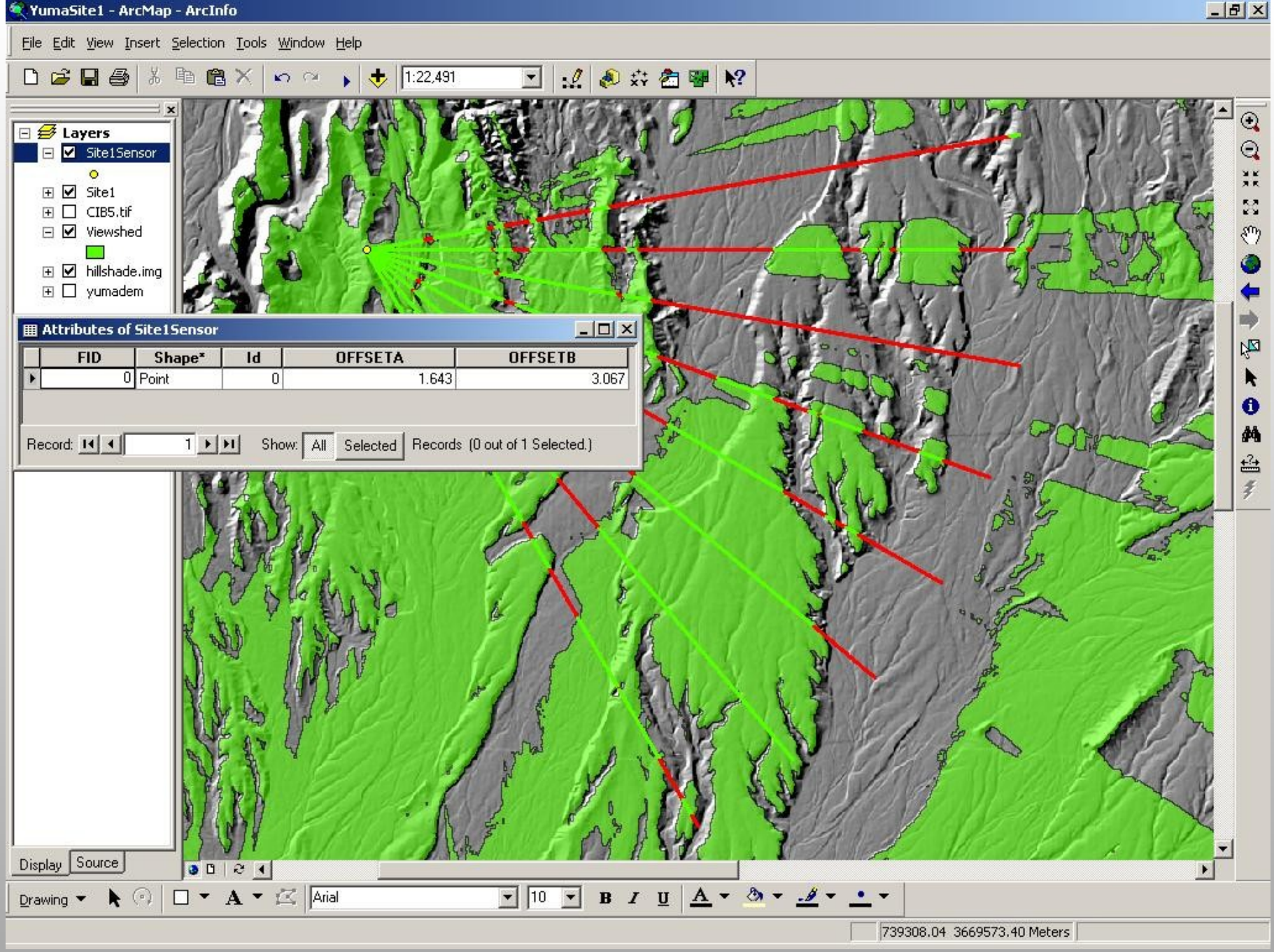
- **Perform spatial queries on polygons derived from the raster viewsheds which determine the percentage agreement of the viewsheds' prediction relative with the field data.**

  (Polygons must exactly fit the visible/masked delineations of the viewsheds from which they are derived.)

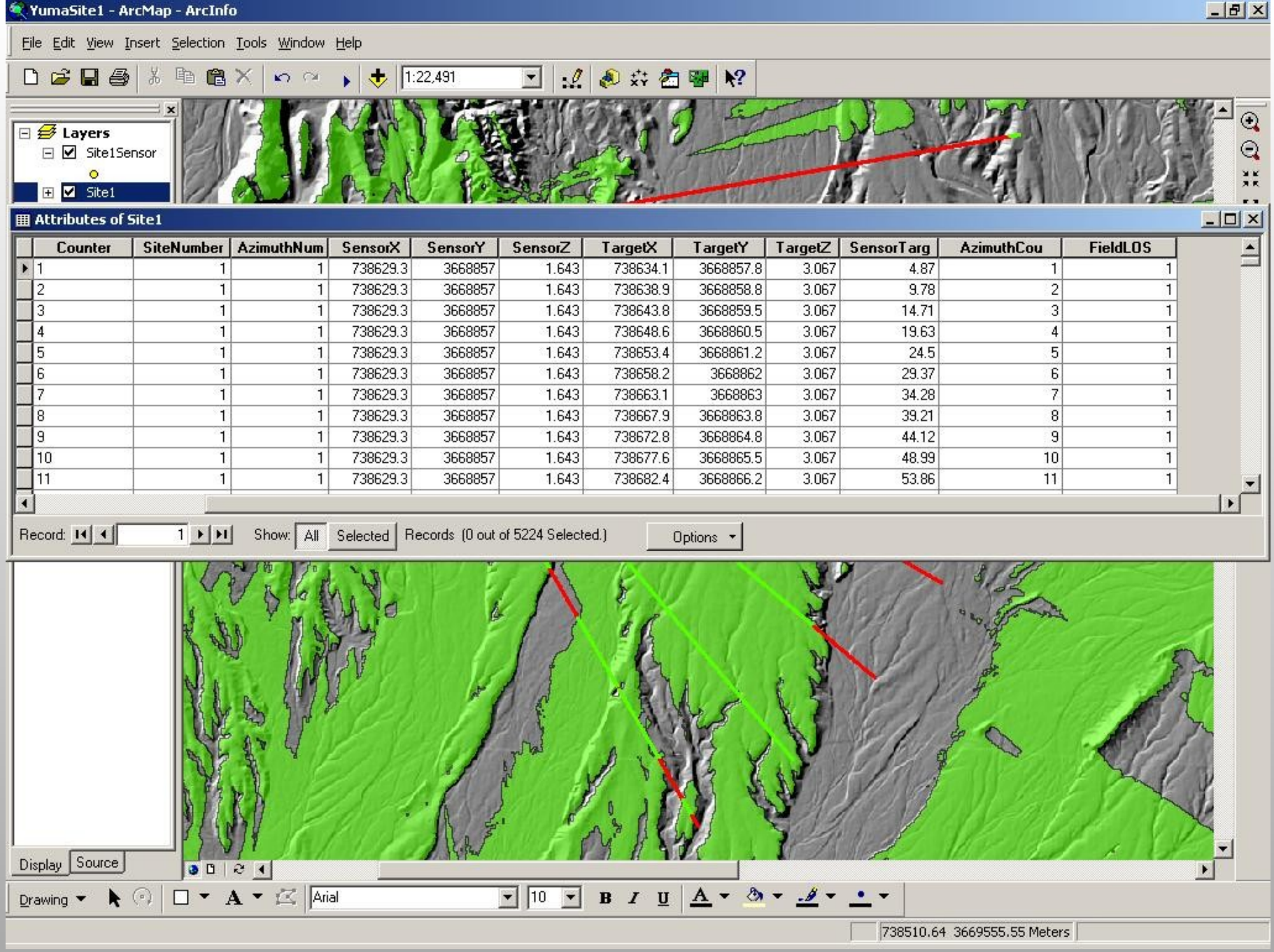
- **Compile statistics in spreadsheets and determine trends based on application results, terrain type, DEM source, DEM accuracy, resolution, precision, etc.**

Requirements/Rules of Thumb for Proper Analysis of Viewshed Overlays Against Field Data

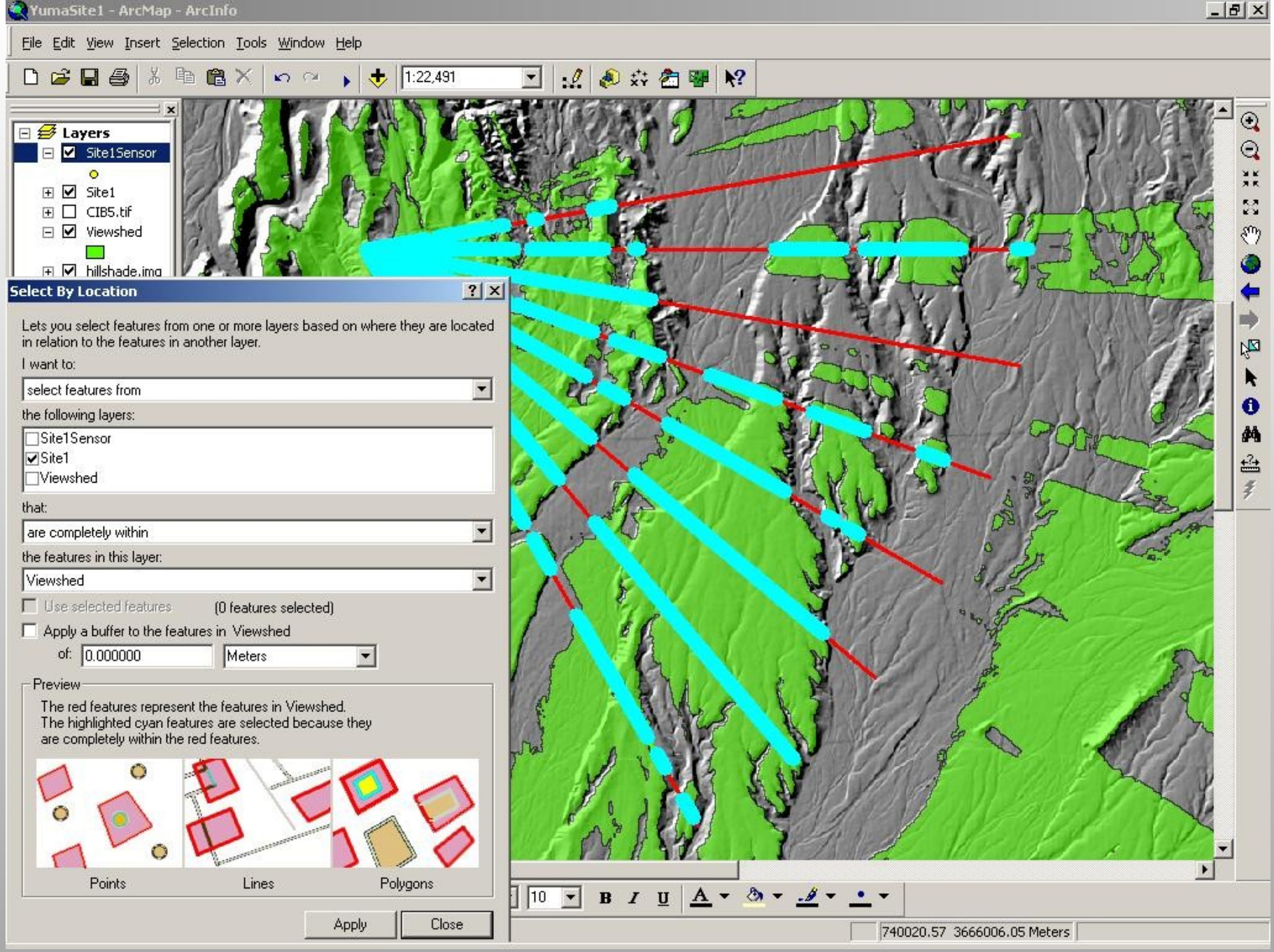
- Projection/datum must be properly defined for import of field and DEM data.
- When datums of field data and a DEM differ, transform observer and field coordinates to the datum of the DEM and run the viewshed in that datum. Avoid resampling of DEM data.
- Observer and target x,y,and z (height above ground) must be precisely defined.
- Earth curvature is to be applied if the application implements it.
- Viewsheds must be georeferenced output and not warped or otherwise resampled by evluation software.
  (Assuming proper georeferencing of application viewsheds, the evaluation software's viewshed application does not gain an advantage)
- For analysis in GIS, raster viewsheds must be converted to polygons to enable spatial queries. The resulting



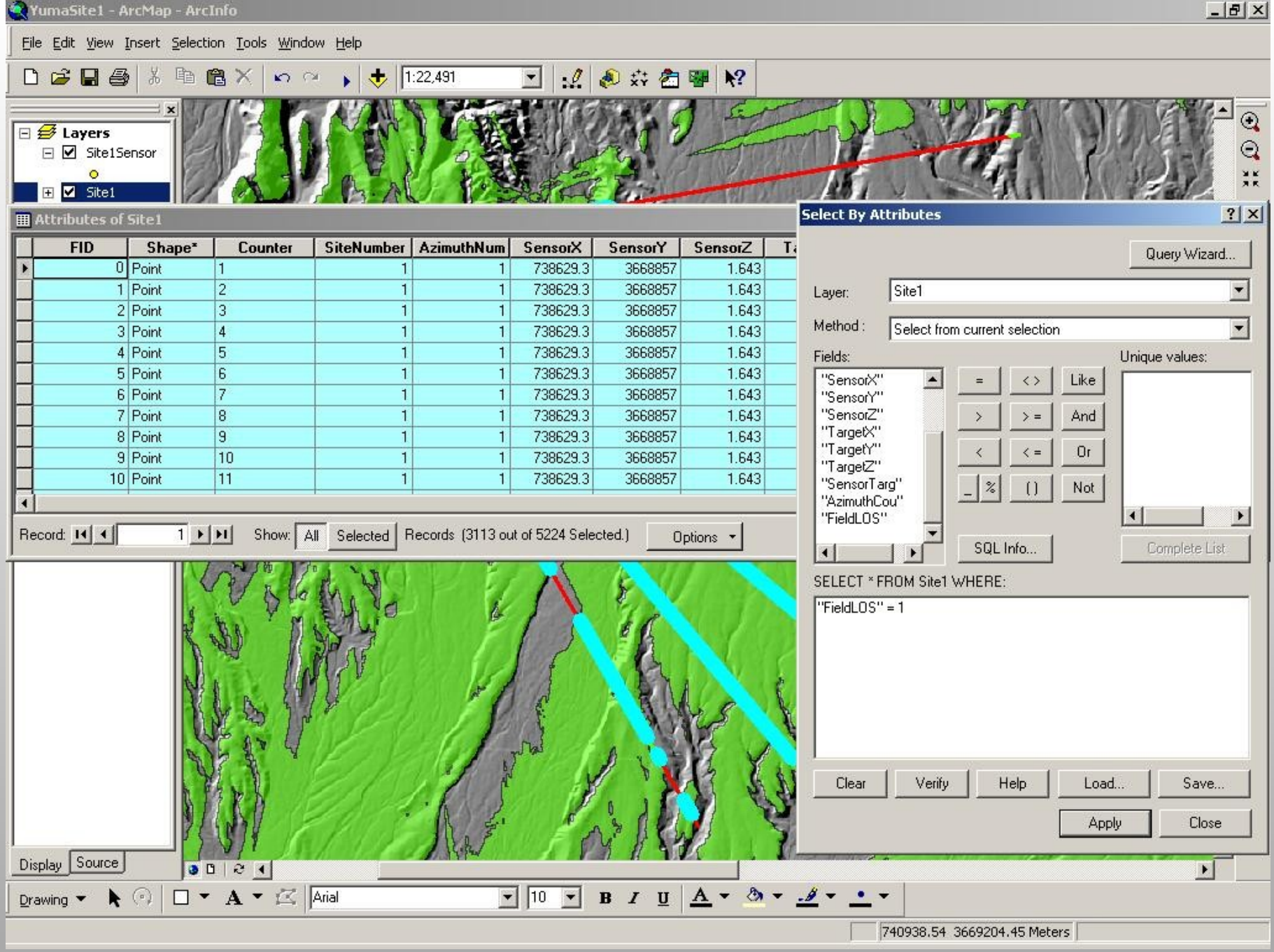
Yuma Site 1 Sensor/Observer Attributes



Yuma Site 1 Field Data Attributes



Query of all Field Points Within Visible Viewshed



Query of Visible Field Points Within Visible Viewshed

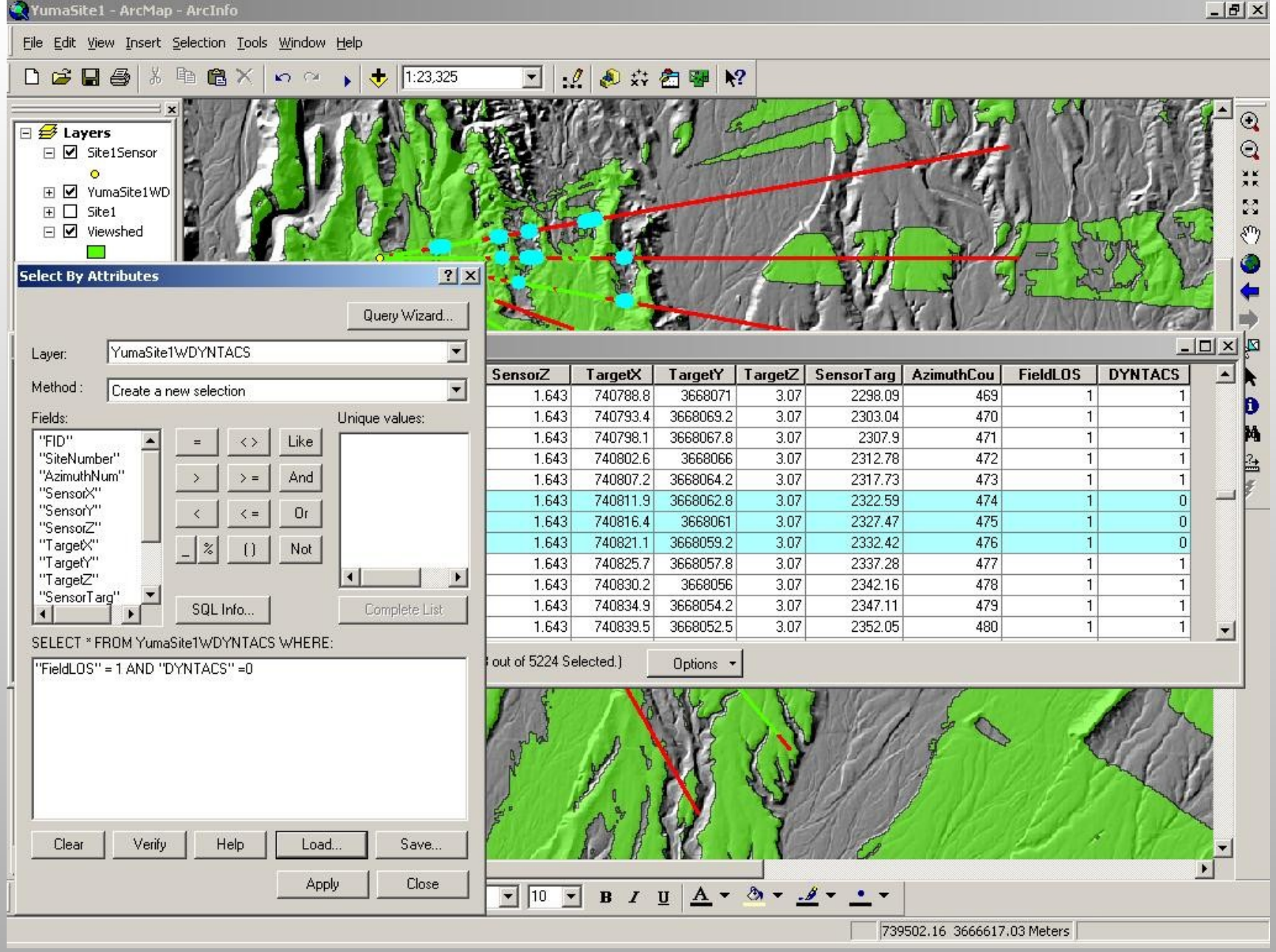
Agreement

Agreement is broken down by

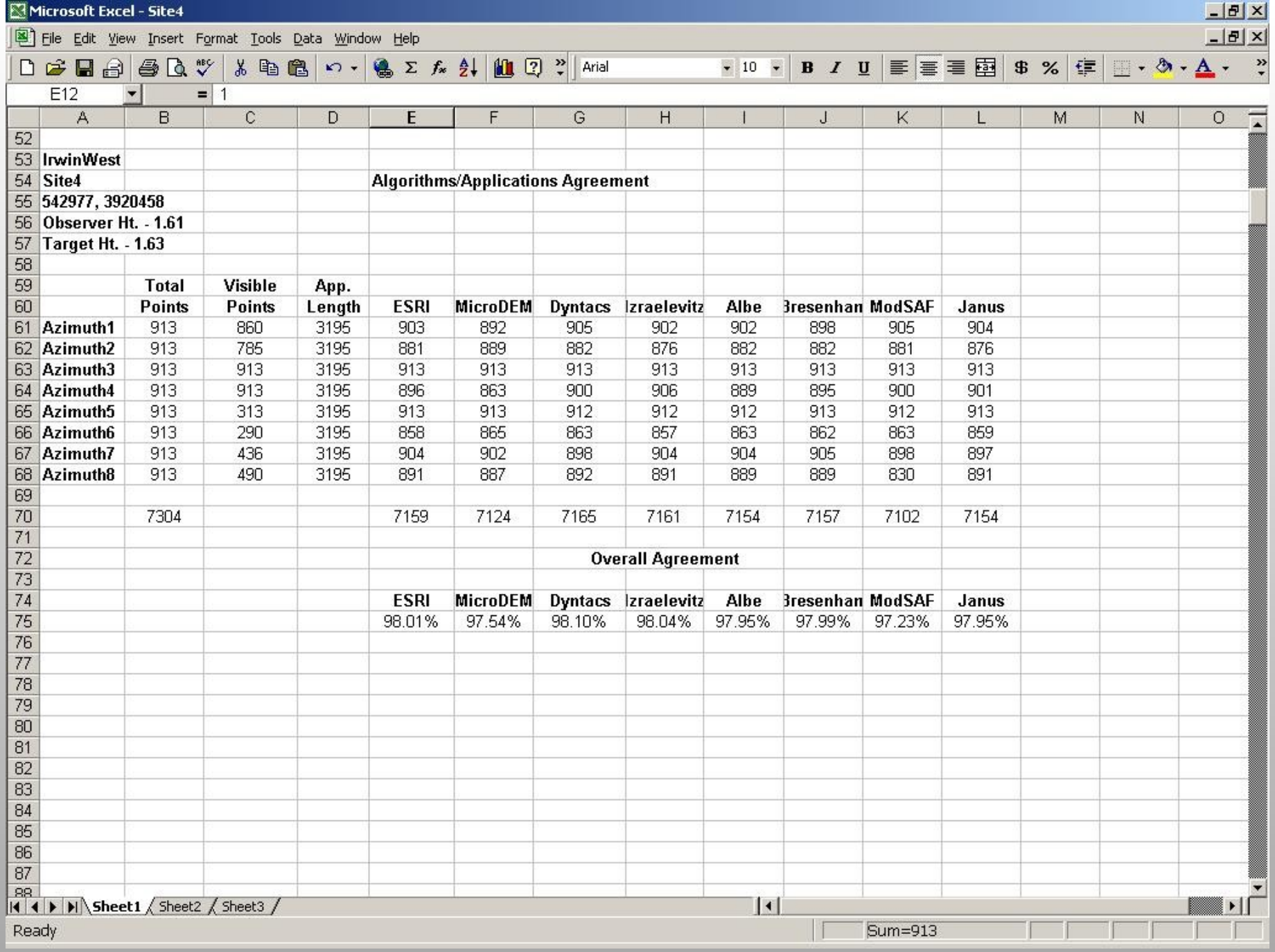
- **Viewshed application/algorithm**

And further by

- **Test Area**
- **Site**



Agreement/Disagreement Between Field Data and Third Party Algorithm/Application



Percent Agreement with Field Data

High Resolution Photogrammetric DEMs

Test Area	DEM Resolution (meters)	Stated DEM Accuracy (meters)		Z-Value Precision (meters)
		Hor.	Vert.	
Fort Benning	1	<1.0	1.0	0.001
Fort Hood	4	N/A	N/A	0.010
Irwin East	5	<1.0	1.0	1.000
Irwin West	5	0.03	0.04	0.100
Twentynine Palms	1	<1.0	0.15	0.100

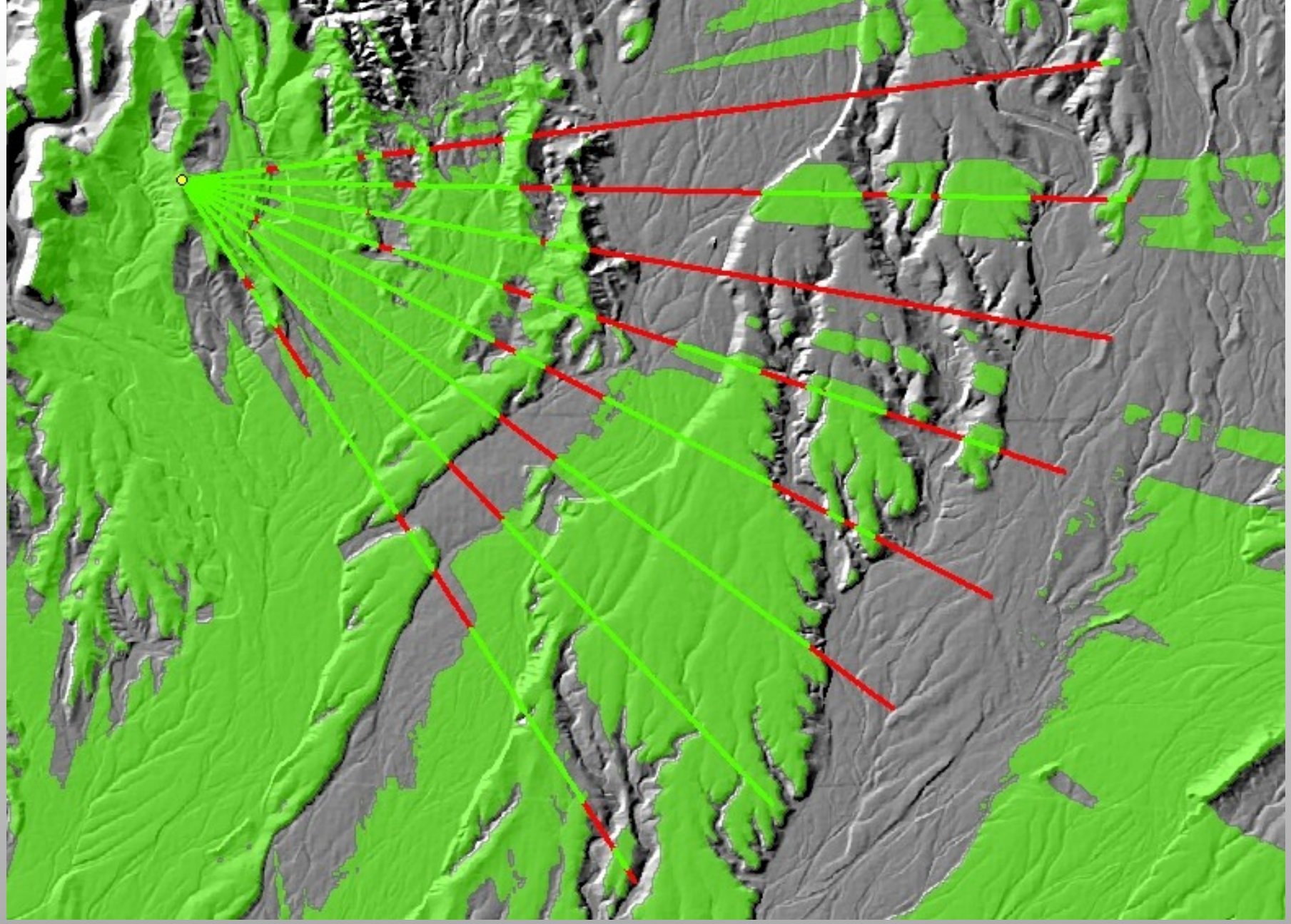
Additional DEM Sources Tested by TEC Over Selected Areas

- **Light Detection and Ranging Data (LIDAR)*
  (1 meter Resolution)**

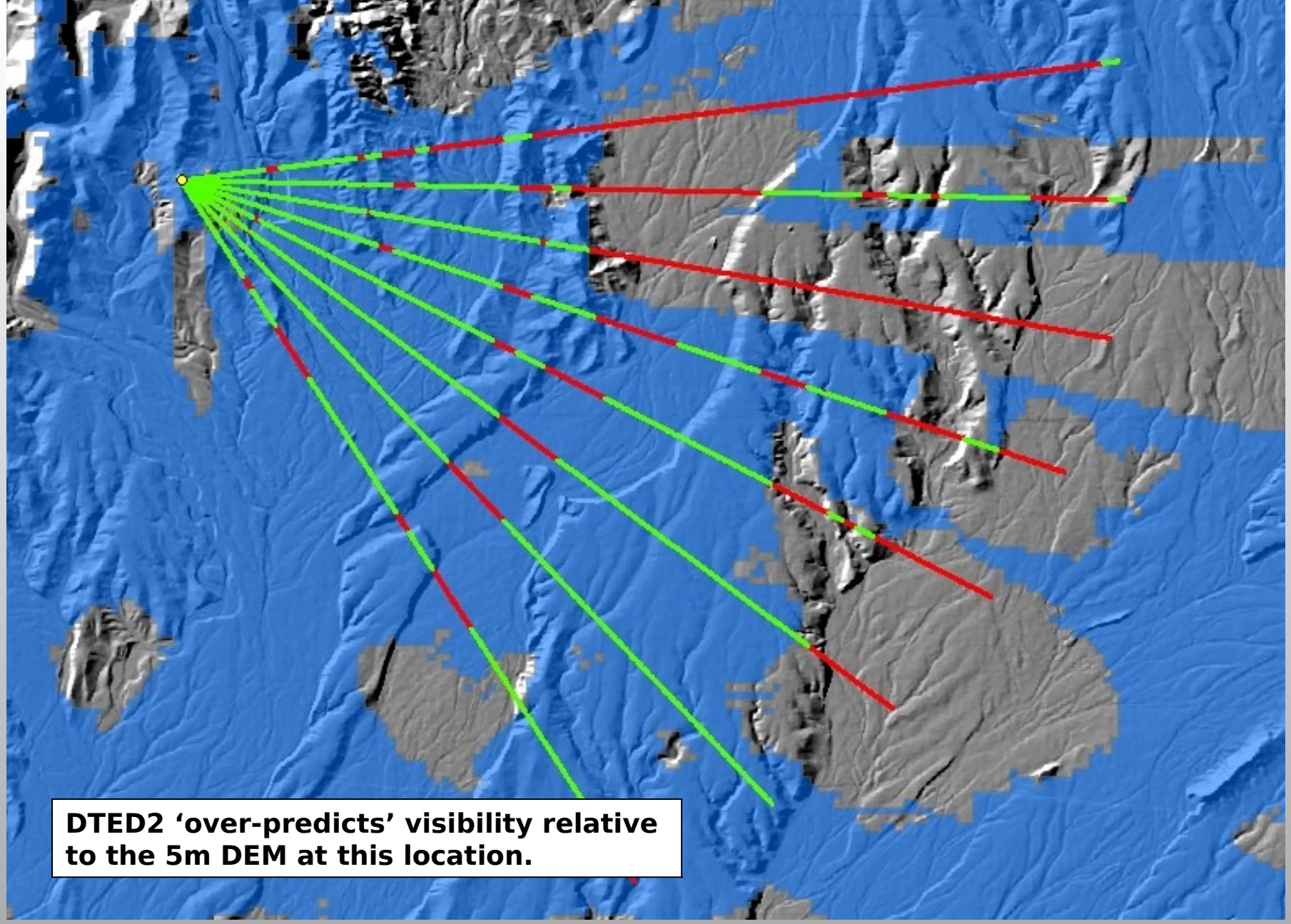
- **Interferometric Synthetic Aperture Radar (IFSARE)*
  (3 Meter Resolution)**

- **DTED2
  (1-Arc Second Posting Interval - ~30 Meter Resolution)**

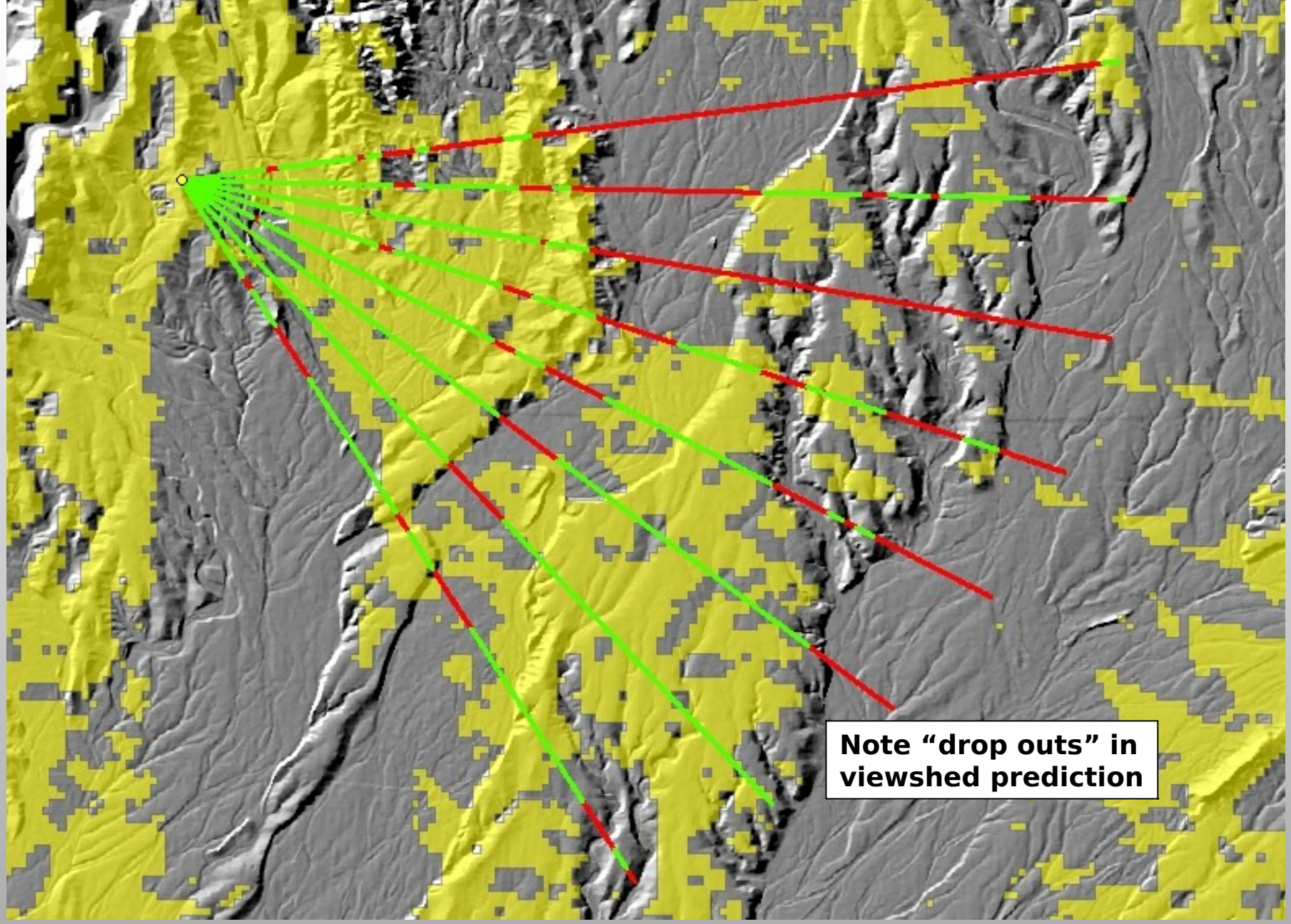
- **Shuttle Radar Topography Mission (SRT2)
  (1-Arc Second Posting Interval - ~30 Meter Resolution)**



Yuma Site1 (3.6 KM x 4.4 KM)
Viewshed from 5 m photogrammetric DEM



Yuma Site1 (3.6 KM x 4.4 KM)
Viewshed from DTED2



Yuma Site1 (3.6 KM x 4.4 KM)
Viewshed from Shuttle Radar Topography Mission (SRTM

Viewshed Applications Tested by the Topographic Engineering Center (to date) Against LOS Field Data Using High Resolution Photogrammetric DEMs, LIDAR, IFSARE, DTED2 and SRT2

- ESRI ArcGIS 8.x Spatial Analyst/3D Analyst
- Intergraph GeoMedia Terrain 5.0
- Battlefield Terrain Reasoning and Awareness (BTRA-LOS) Viewshed
- MicroDEM/TerraBase II 7.0
- US Army Digital Topographic Support System (DTSS) 7.1.1

Algorithms Run By US Army Training and Doctrine Command Analysis Center, White Sands Missile Range (TRAC-WSMR) Against LOS Field Data Using High Resolution DEMs*

- Dynamic Tactical Simulation (DYNTACS)
- Modular SemiAutomated Forces (ModSAF)
- Bresenham
- Janus

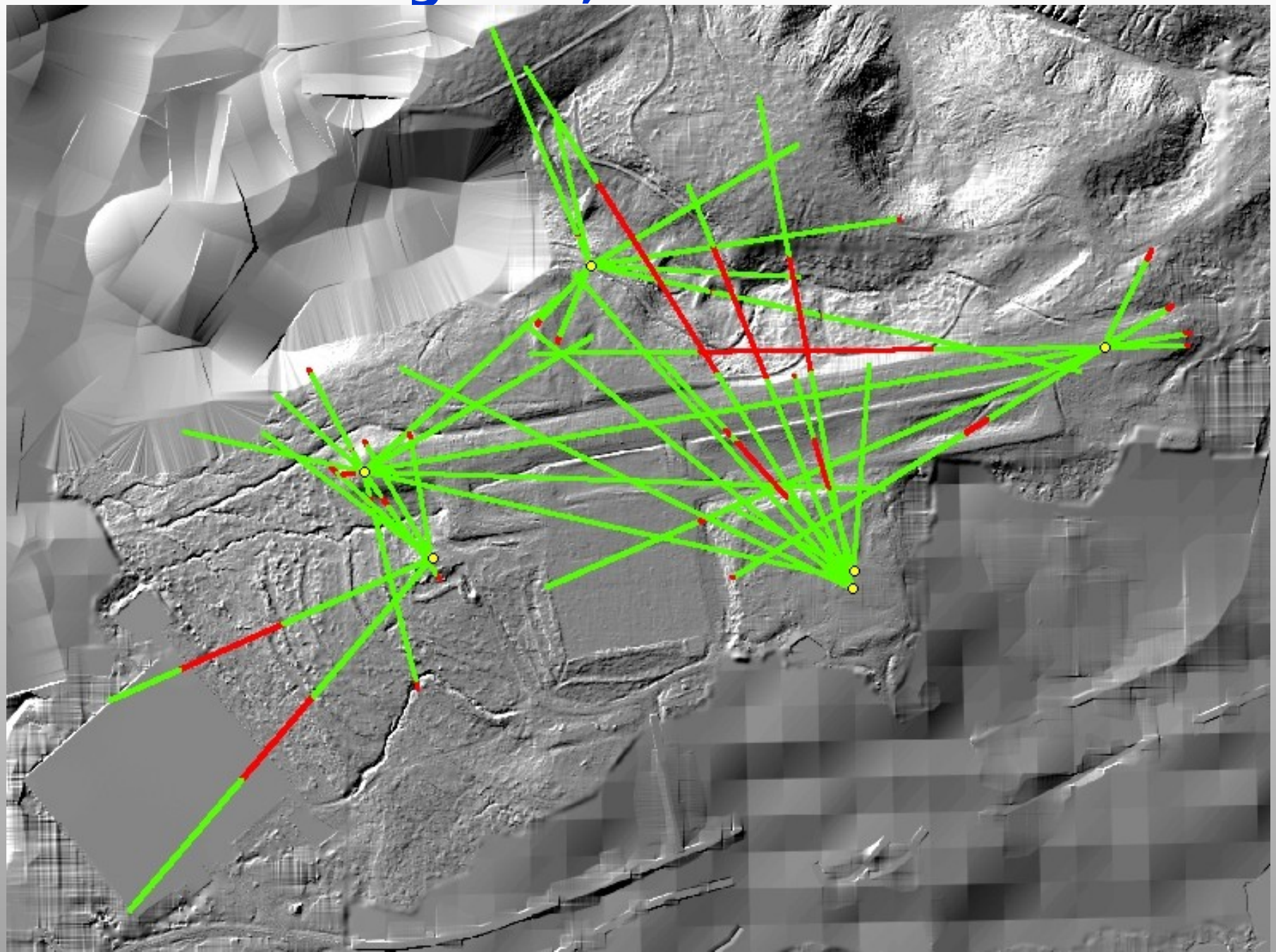
* Details on these algorithms may be found in “The Effects of Different Line-of-Sight Algorithms and Terrain Elevation Representations on Combat Simulations”, Champion, Pankratz, and Fatale, 1995.

Fort Benning

Field Data

- 6 observer sites
- 41 azimuths collected over 1.2 km x 1.5 km area
- Azimuth Lengths – 110 to 1059 meters
- 36,684 total observed points (18,342 points collected at 2 target heights) sampled every 0.9 meters
- Observer heights (meters) – 1.075, 1.657, 1.676, 1.689, 1.727, 11.498
- Target heights (meters) - 1 and 1.6 (all)
- UTM WGS84 zone 16

Fort Benning – 18,342 Observed Points

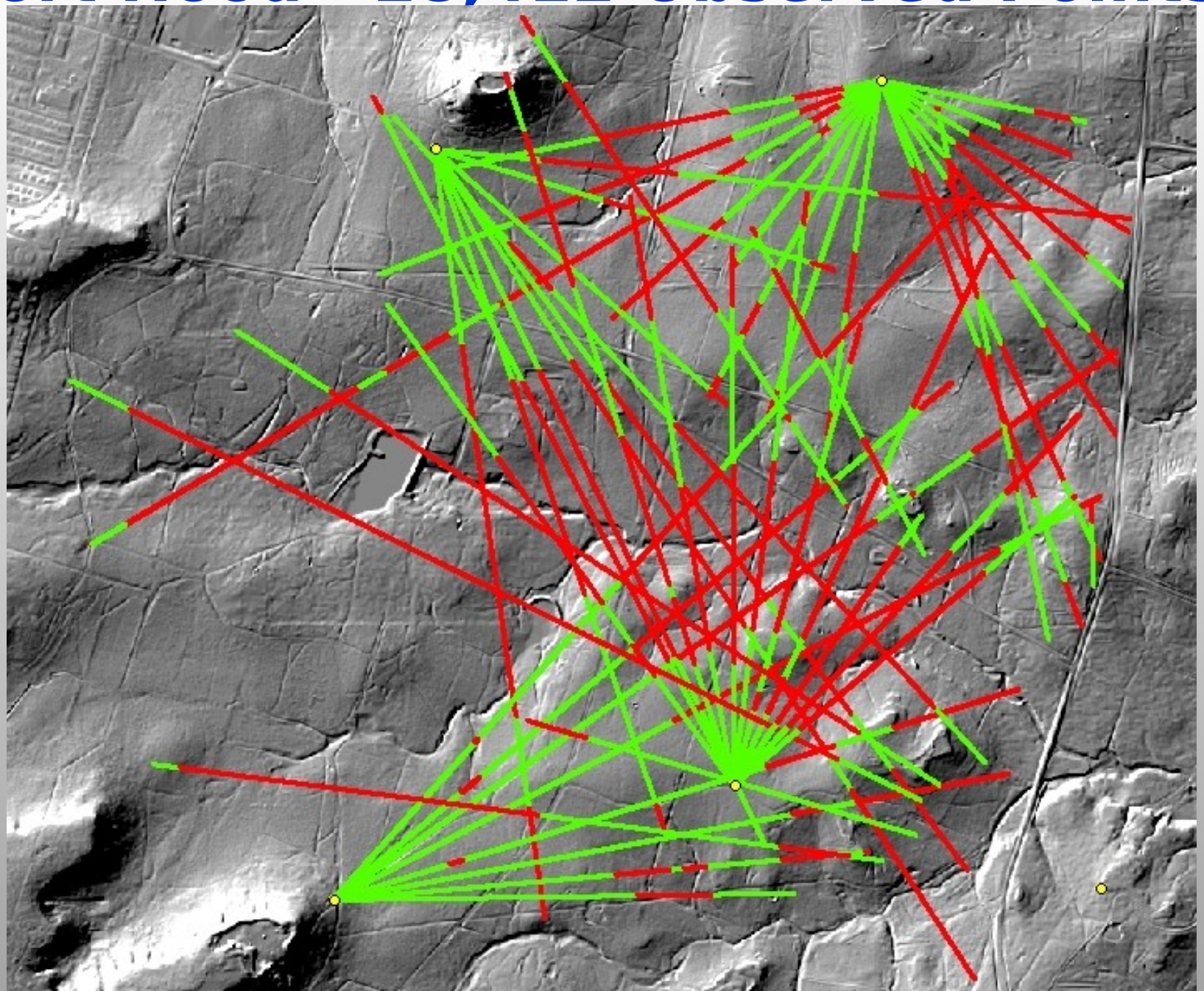


Fort Hood

Field Data

- 7 observer sites
- 51 azimuths collected over 3.4 km x 3.7 km area
- Azimuth Lengths - 195 to 947 meters
- 28,412 observed points sampled every 3.5 meters
- Observer heights (meters) – 1.651, 1.607, 1.715, 1.664, 1.676, 1.632, 1.651
- Target heights (meters) – 1.930 (1 site), 1.969 (4 sites), 1.829 (2 sites)
- UTM WGS84 zone 14

Fort Hood - 28,412 Observed Points

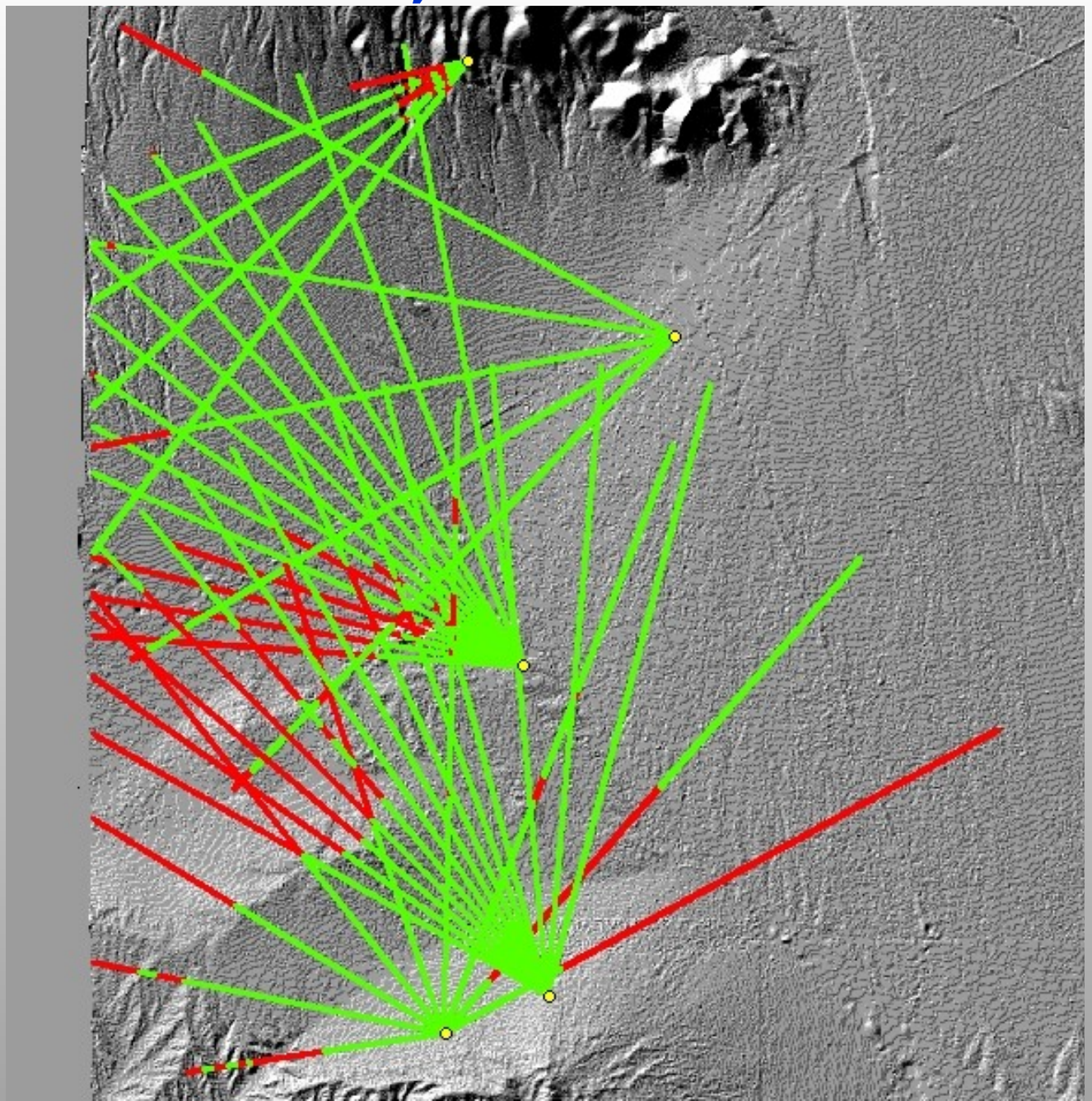


Irwin East

Field Data

- 5 observer sites
- 47 azimuths collected over 4.9 km x 5.5 km area
- Azimuth Lengths – 595 – 3195 meters
- 37,077 observed points sampled every 3.5 meters
- Observer heights (meters) – 1.75 (all)
- Target heights (meters) – 1.63 (all)
- UTM WGS84 zone 11

Irwin East – 37,077 Observed Points

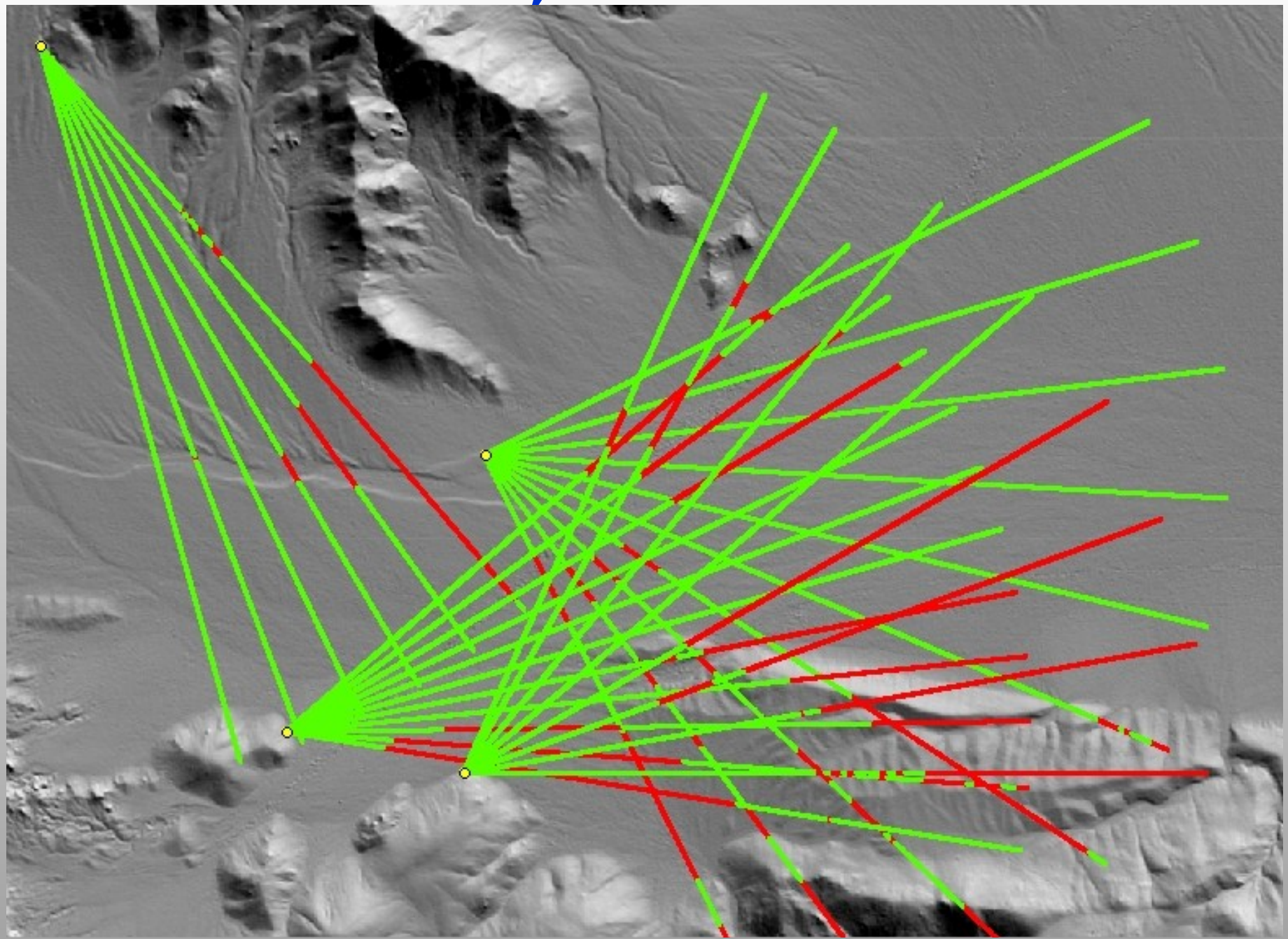


Irwin West

Field Data

- 4 observer sites
- 35 azimuths collected over 4.0 km x 5.3 km area
- Azimuth Lengths – 2324 – 3195 meters
- 31,483 observed points sampled every 3.5 meters
- Observer heights (meters) – 1.55 (2 sites), 1.49, 1.61
- Target heights (meters) – 1.63 (all)
- UTM WGS84 zone 11

Irwin West – 31,483 Observed Points

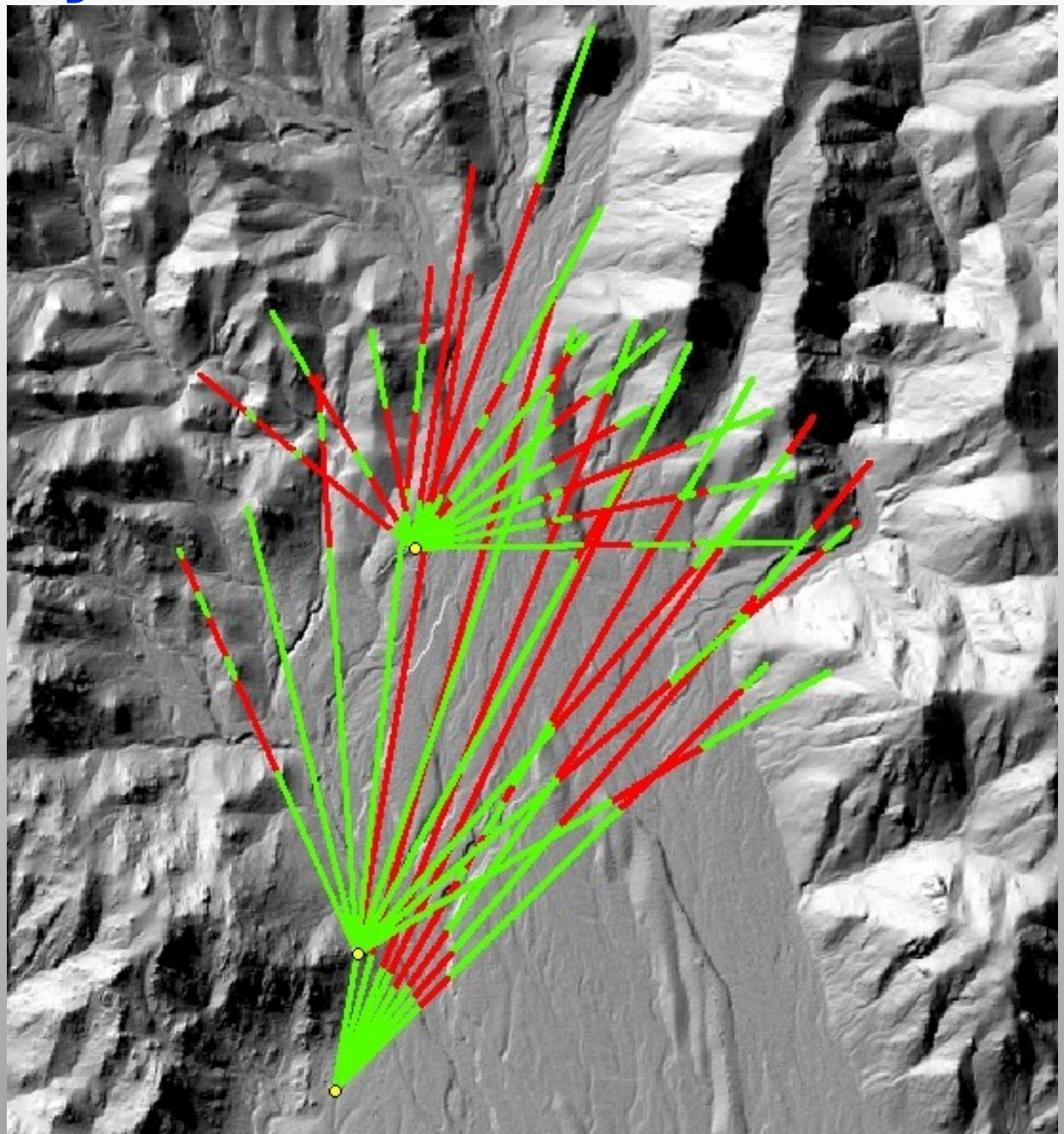


Twentynine Palms

Field Data

- 3 observer sites
- 29 azimuths collected over 1.3 x 2.4 km area
- Azimuth Lengths – 395 – 1494 meters
- 8163 observed points sampled every 3.5 meters
- Observer heights (meters) – 1.75 (all)
- Target heights (meters) – 1.75 (all)
- UTM WGS84 zone 11

Twentynine Palms – 8163 Observed

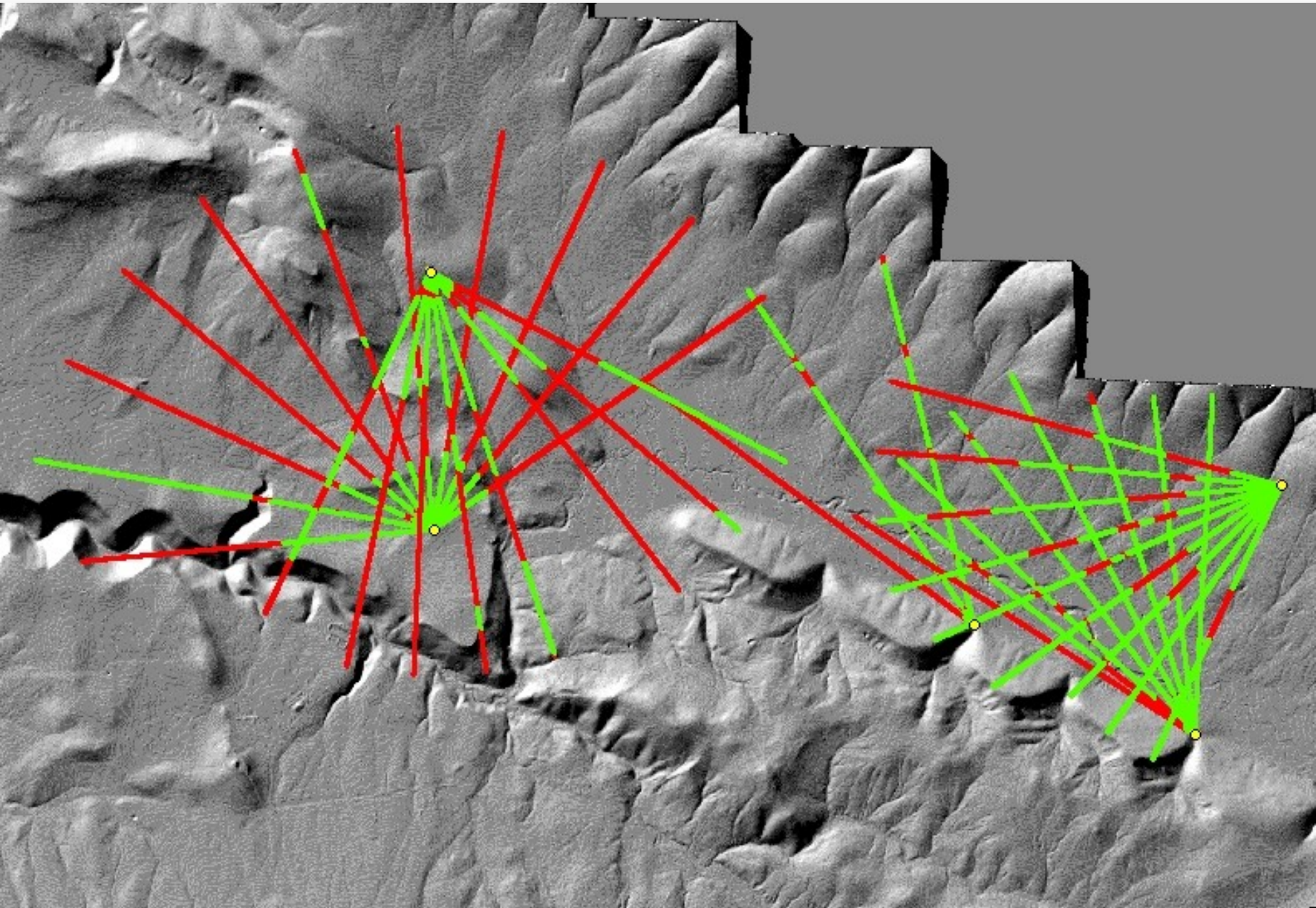


Yakima

Field Data

- 5 observer sites
- 39 azimuths collected over 5.3 x 10.2 km area
- Azimuth Lengths – 2355 – 3195 meters
- 34,109 observed points sampled every 3.5 meters
- Observer heights (meters) – 1.75 (all)
- Target heights (meters) – 2.11 (all)
- UTM NAD83 zone 10

Yakima – 34,109 Observed Points

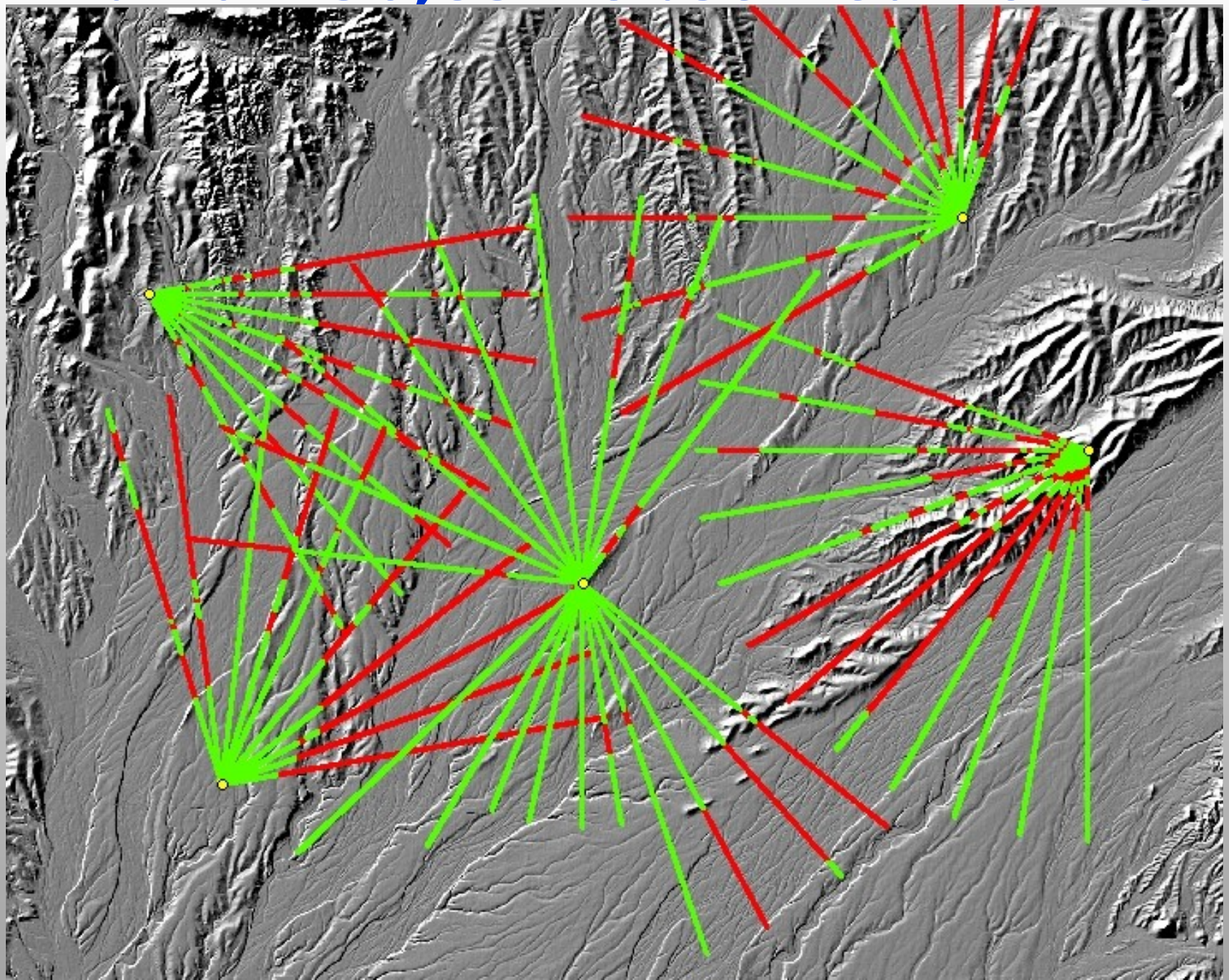


Yuma

Field Data

- 5 observer sites
- 39 azimuths collected over 7.8 x 8.3 km area
- Azimuth Lengths – 1715 – 3200 meters
- 30,837 observed points sampled every 5 meters
- Observer heights (meters) – 1.643, 1.615, 1.618, 1.560, 1.630
- Target heights (meters) – 3.067 (all)
- UTM WGS84 zone 11

Yuma – 30,837 Observed Points



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703-428-6785